

FORM PTO-1390 REV. 5-93		US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEYS DOCKET NUMBER P99,2604
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/485525
INTERNATIONAL APPLICATION NO. PCT/DE98/02109	INTERNATIONAL FILING DATE 27 JULY 1998	PRIORITY DATE CLAIMED 13 AUGUST 1997	
TITLE OF INVENTION METHOD FOR THE STATISTICAL MULTIPLEXING OF ATM CONNECTIONS			
APPLICANT(S) FOR DO/EO/US DOROTHEA LAMPE ET AL			
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. <input checked="" type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. <input checked="" type="checkbox"/> A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached. <ol style="list-style-type: none"> <input checked="" type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). <input type="checkbox"/> has been transmitted by the International Bureau. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US) <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)) - drawings attached. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3)) <ol style="list-style-type: none"> <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). <input type="checkbox"/> have been transmitted by the International Bureau. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. <input type="checkbox"/> have not been made and will not be made. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). <input checked="" type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). <p>Items 11. to 16. below concern other document(s) or information included:</p> <ol style="list-style-type: none"> <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; (PTO 1449, Prior Art, Search Report). <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. (SEE ATTACHED ENVELOPE) <input checked="" type="checkbox"/> Amendment "A" prior to action. <ul style="list-style-type: none"> <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. <input type="checkbox"/> A substitute specification. <input type="checkbox"/> A change of power of attorney and/or address letter. <input checked="" type="checkbox"/> Other items or information: <ol style="list-style-type: none"> <input checked="" type="checkbox"/> EXPRESS MAIL # EL408261232US dated February 9, 2000. 			

APPLICATION NO. (37 C.F.R. 1.51)

09/485525

INTERNATIONAL APPLICATION NO
PCT/DE98/02109ATTORNEY'S DOCKET NUMBER
P99,2604

17. The following fees are submitted:

BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):

Search Report has been prepared by the EPO or JPO \$840.00

International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) .. \$670.00

No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but
international search fee paid to USPTO (37 C.F.R. 1.445(a)(2)) \$760.00Neither international preliminary examination fee (37 C.F.R. 1.482) nor international
search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO \$970.00International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all
claims satisfied provisions of PCT Article 33(2)-(4) \$ 96.00**ENTER APPROPRIATE BASIC FEE AMOUNT =**

CALCULATIONS

PTO USE ONLY

\$ 840.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months
from the earliest claimed priority date (37 C.F.R. 1.492(e)).

\$

Claims	Number Filed	Number Extra	Rate
Total Claims	09 - 20 =	0	X \$ 18.00
Independent Claims	01 - 3 =	0	X \$ 78.00
Multiple Dependent Claims			\$260.00 +
TOTAL OF ABOVE CALCULATIONS =			

\$

Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also
be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)

\$

SUBTOTAL =

\$ 840.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months
from the earliest claimed priority date (37 CFR 1.492(f)).

\$

TOTAL NATIONAL FEE =

\$ 840.00

Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be
accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property

+

TOTAL FEES ENCLOSED =

\$ 840.00

Amount to be
refunded

\$

charged

\$

a. ☒ A check in the amount of \$ 840.00 to cover the above fees is enclosed.b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A
duplicate copy of this sheet is enclosed.c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 08-2290. A duplicate copy of this sheet is enclosed.NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be
filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Hill & Simpson
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SIGNATURE

Melvin A. Robinson

NAME

31,870

Registration Number

-1-

BOX PCT
IN THE UNITED STATES ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

5

AMENDMENT "A" PRIOR TO ACTION

APPLICANT(S): Dorothea Lampe et al DOCKET NO: P99,2604

SERIAL NO: GROUP ART UNIT:

EXAMINER:

INTERNATIONAL APPLICATION NO: PCT/DE98/02109

10 INTERNATIONAL FILING DATE: 27 July 1998

INVENTION: **METHOD FOR THE STATISTICAL MULTIPLEXING
OF ATM CONNECTIONS**Assistant Commissioner for Patents,
Washington, D.C. 20231

15 Sir:

Applicants amend the above-identified PCT application as follows,
and request entry of the Amendment prior to examination in the United
States National Examination Phase.

IN THE SPECIFICATION:

20

On page 1:

delete lines 4 and 5 and insert the following heading and paragraph:

--BACKGROUND OF THE INVENTION

The present invention relates to transmission of information via
asynchronous transfer mode (ATM) and, more particularly, to a method
25 for the statistical multiplexing of ATM connections.--;

line 6, replace "plurality" with --number-- and delete "are defined
given connections";

line 7, replace "are" with --is--;

line 8, after "(ATM)" insert --are known--; and replace "Thus, on the one hand, connections" with --Connections--;

line 12, replace "are" with --is--;

5 line 13, replace "are" with --is--; and after "with" insert --a--;

line 16, replace "are" with --is--;

line 18, after "five" insert --above--; and replace "are" with --is--;

line 19, replace "in common" with --together--; and delete " ,
respectively,";

10 line 20, replace "the setup of" with --setting up--; and

line 22, delete "that is".

On page 2:

line 4, replace "this all" with --discarding cells--;

15 line 5, replace "the demand for" with --standardization authorities
require--; replace "properly" with --property--; and replace "of" with --for--;

line 6, delete "exists on the part of standardization authorities";

line 7, replace "already carried out" with --performed--; and
replace "as to" with --to determine--;

line 13, delete "thereby";

20 line 14, replace "plurality" with --number--; and replace "of" with --
via--;

line 18, replace "maximally" with --maximum--;

line 20, replace "maximally" with --maximum--;

line 21, replace "quasi material" with --quasi-material--;

25 line 23, replace "maximally" with --maximum--;

line 24, replace "maximally" with --maximum--;

line 27, replace "sequences" with --sequence utilized--; and

line 29, after "these" insert --parameters--.

On page 3:

line 4, replace “Let the” with --The--; and replace “be recited here as” with --is an example of--;

line 6, replace "A" with --An--;

5 line 10, after “when” insert --the following condition (b) is met--;

line 11, after “as” insert --will be--; and after “later” delete --, the following--;

line 12, delete "condition (b) is met";

line 16, delete "thus,";

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10 line 18, delete "to" (second occurrence);
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line 22, after "as" insert --a--; and

line 24, replace "multiplex" with --multiplexed--.

On page 4:

line 1, after "These" insert --connections--;

15 line 4, replace “very close to one another - or very far from one another” with --either very close to or very far from one another--;

line 6, replace "then" with --than--;

line 7, replace “maximally” with `--maximum--`; and after “as” insert

20 line 12, delete “from dynamics points of view”;

line 15, replace “, thus a” with --an--;

line 22, replace “then the maximally” with --than the maximum--;

line 23, after "then" insert --the--;

line 28, replace “then” with --than--; and

25 line 31, replace "is in turn" with --is, in turn,--.

On substitute page 5:

line 1, delete "thus,";

line 3, (second occurrence) delete "to";

line 8, after "modification" insert --, as shown in Equation (c),--;

5 line 12, after "/c" insert --.--;

line 14, delete "thus"; and delete ", for";

line 15, replace "example" with --(e.g.,--; and replace "line," with --line)--;

line 17, after "whether" insert --or not--;

10 line 18, delete "or not";

line 24, delete "comprised therein"; and

line 25, replace "per" with --for each--.

On substitute page 5a:

line 9, delete ", respectively,"; and

15 delete lines 11-13, and insert the following heading and paragraph:

--SUMMARY OF THE INVENTION

The present invention teaches a method of how to fashion an acceptance algorithm such that a bandwidth representative for all
20 connections can be calculated in an efficient way.--.

On page 6:

delete lines 1-3 and insert the following:

--According to an aspect of the invention, a method for statistical multiplexing of ATM connections includes conducting a plurality of ATM
25 connections over a common connecting line. The plurality of ATM connections have an effective bandwidth reserved for conduction of the aggregate of the plurality of ATM connections on the connecting line and

utilize an acceptance algorithm that allocates potential added connections to one of a first class and a second class. The method also includes deciding whether additional potential added connections can be accepted on the common connecting line based on acceptance criteria and a prescribed effective bandwidth. This decision includes first identifying the prescribed effective bandwidth on a step-by-step basis for either a setup connection or a release of a connection wherein the identification starts from an initial value and the acceptance algorithm is then performed at every step. Additionally, the method determines whether at least one of the additional potential added connections or release connections may be accepted by at least one of the first class and the second class. Next, the method defines a first bandwidth representative of the first class and the second bandwidth representative of the second class and then modifies at least one of the first and second bandwidths by at least a first traffic parameter value or a second traffic parameter value based on the acceptance of the additional potential added connection to at least one of the first and second class. Finally, the method either accepts or rejects an additional potential added connection based on at least the identified prescribed effective bandwidth and the acceptance criteria.--;

20 line 4, replace "for" with --in--;
 line 5, after "as" insert --an--; and after "bandwidth" delete --,--;
 line 6, delete ", ";
 line 9, replace "criteria, a" with --criteria and a--;
 line 11, delete ", respectively,";
25 line 16, delete ", respectively,"; and
 delete lines 19-31 and insert the following headings and paragraphs:

 --Additional advantages and novel features of the invention will

be set forth, in part, in the description that follows and, in part, will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The advantages of the invention may be realized and attained by means of the
5 instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference is made to the attached drawings wherein:

Figure 1 illustrates a flow chart according to the inventive method;

10 and

Figure 2 illustrates a flow chart according to an alternate embodiment of the inventive method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a flow chart according to the inventive method.

15 The initially described sigma rule algorithm SR of the prior art is employed as an acceptance algorithm. In accordance therewith, additional status variables are introduced in addition to the status variable carried in the sigma rule algorithm SR. These status variables are c_k^S , c_k^P and c_k^{eff} .

On page 7:

20 line 1, replace "variables" with --variable--;
line 3, replace "variables" with --variable--;
line 5, replace "variables" with --variable--;
line 6, replace "What thus" with --The relationship that--;
line 8, replace ",", (first occurrence) with --and--;
25 line 10, before "2)" insert --and--;
line 11, replace "are [sic]" with --is--; and
line 26, after "added" delete --,--.

On page 8:

line 3, replace "A security in the estimate is thus established."
with --Thus, reliability in the estimate is established.--;

line 5, replace "then" with --that point--;

5 line 6, replace "new," with --the new--;

line 7, replace "derives" with --condition applies--;

line 10, replace "then" with --that point--;

line 11, replace "new," with --the new--; and after "." insert --

Accordingly, the following condition applies--; and

10 line 21, before ":" insert --as follows--.

On page 9:

line 10, replace "appertaining" with --pertaining--.

On page 10:

line 3, replace "then" with --this point--;

15 line 4, replace "new," with --the new--;

line 7, replace "then" with --this point--;

line 8, after "as" insert --the--; and

line 15, before ":" insert --as follows--.

On page 11:

20 line 3, replace "development" with --embodiment--; and delete "is
provided to replace";

line 4, replace "with" with --can be replaced with--;

line 8, after "are" insert --illustrated at step S--; and

after line 8, insert the following paragraph:

25 --While this invention has been described in connection with what
is presently considered to be the most practical and preferred
embodiments, it is to be understood that the invention is not limited to the

disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.--.

IN THE CLAIMS:

5 **Delete claims 1-9 on substitute pages 12-14, without
prejudice or disclaimer and insert new claims 10-18 as follows:**

10. A method for statistical multiplexing of ATM connections
comprising:

10 conducting a plurality of ATM connections over a common
connecting line, the plurality of ATM connections having an effective
bandwidth reserved for conduction of the aggregate of the plurality of
ATM connections on the connecting line and utilizing an acceptance
algorithm that allocates potential added connections to one of a first class
and a second class; and

15 deciding whether an additional potential added connection can be
accepted by the common connecting line based on acceptance criteria
and a prescribed effective bandwidth, the deciding step comprising the
steps of:

20 identifying the prescribed effective bandwidth on a step-by-step
basis with at least one of a setup and a release of connection, wherein the
identification starts from an initial value and the acceptance algorithm is
performed at every step;

25 determining whether at least one of the additional potential
added connection or a released connection may be accepted by at least
one of the first class and the second class;

defining a first bandwidth representative of the first class and a second bandwidth representative of the second class;

modifying at least one of the first and second bandwidths by at least one of a first traffic parameter value and a second traffic parameter value based on the acceptance of the additional potential added connection to at least one of the first class and the second class; and

at least one of accepting and rejecting the additional potential added connection based on at least the identified prescribed effective bandwidth and the acceptance criteria.

11. The method according to claim 10, wherein the first traffic parameter value is a sustainable cell rate and the second traffic parameter value is a peak cell rate of the corresponding connection.

12. The method according to claim 10, wherein at least one of the acceptance criteria is established such that, in the case of the connection setup, when the additional potential added connection can be accepted to the first class, a calculation is performed to determine whether the first bandwidth identified is adequate including this connection, wherein the first bandwidth is not allowed to exceed the sum of the peak cell rates of all connections and the first bandwidth is incremented by the first traffic parameter value when the at least one of the acceptance criteria is met and the first bandwidth is incremented by the second traffic parameter value when the at least one of the acceptance criteria is not met.

13. The method according to claim 12, wherein when the additional potential added connection cannot be allocated to the first class, it is automatically allocated to the second class and the second bandwidth is

incremented by the second traffic parameter value.

14. The method according to claim 10, wherein at least one of the acceptance criteria is established such that, in the case of the connection release when the released connection can be accepted by the first class, a calculation is performed to determine whether the first bandwidth, exclusive of this connection, is adequate for the remaining connections, wherein the first bandwidth is not allowed to exceed the sum of the peak cell rates of all connections and the first bandwidth is diminished by the second traffic parameter value when the at least one of the acceptance criteria is met and the first bandwidth is diminished by the first traffic parameter value when the at least one of the acceptance criteria is not met.

15. The method according to claim 14, wherein when the connection to be released cannot be allocated to the first class, it is automatically allocated to the second class and the second bandwidth is diminished by the second traffic parameter value.

16. The method according to claim 11, wherein at least one of the acceptance criteria is established such that when the connection to be released is allocated to the first class, a calculation is performed to determine whether the first bandwidth without this released connection is adequate for the remaining connections; and wherein the first bandwidth is diminished by the second traffic parameter value when the at least one acceptance criterion is met and the value of the identified first bandwidth is upwardly limited by the sum of the peak cell rates of the first class.

17. The method according to claim 11, wherein the effective bandwidth is derived from the sum of the first and second bandwidth.

18. The method according to claim 11, wherein the acceptance algorithm is started only once per connection to be one of potentially added and released.

IN THE ABSTRACT:

On page 15, delete lines 3-11 and insert the following new Abstract:


--In ATM connections, a number of connections are transmitted over common connecting sections. Connections being newly added to the number of connections are allowed according to the criterion of decisions undertaken by acceptance algorithms. The bandwidth of the totality of all the connections is estimated step-by-step with the setup/release of connections using a modification of the sigma rule algorithm.--.

REMARKS

The present amendment makes editorial changes to the specification, drawings, claims and Abstract in order to conform to United States Patent Practice. Additionally, the Applicants include herewith a copy of the new Abstract on a separate page. None of the changes in the claims is intended as a surrender of any of the subject matter within the scope of the original claim language since, as noted above, all of these changes have been made solely to bring the claims into conformity with the requirements of 35 U.S.C. §112, second paragraph.

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Method for Statistical Multiplexing of ATM Connections

In ATM connections, a number of connections are transmitted over common connecting sections. Connections being newly added to the number of connections are allowed according to the criterion of decisions undertaken by acceptance algorithms. The bandwidth of the totality of all the connections is estimated step-by-step with the setup/release of connections using a modification of the sigma rule algorithm.

SPECIFICATION**METHOD FOR THE STATISTICAL MULTIPLEXING OF ATM
CONNECTIONS**

5 The invention is directed to a method according to the preamble of patent claim 1.

10 A plurality of connection types are defined given connections via which information are transmitted according to the asynchronous transfer mode (ATM). Thus, on the one hand, connections having strict demands made of the cell delay times are distinguished from connections that do not make strict demands of the cell delay times.

15 Particularly included among the former are connections with which information are transmitted with a constant bit rate (CBR) as well as connections via which real time information are transmitted with variable bit rate (rt-VBR).

20 The latter include non-real-time VBR connections (nrt-VBR) or connections via which information are transmitted with a variable bit rate (available bit rate, ABR) or unspecified bit rate connections (UBR).

25 The information of all five connection types are conducted in ATM cells in common via virtual paths or, respectively, virtual lines having a predetermined bit rate (bandwidth). In the course of the setup of new connections that have strict demands made of the cell delay times, it is required to calculate the bandwidth that is required for the totality of all connections conducted over a connecting section/connecting line or a virtual path. For calculating an effective bandwidth, it is necessary to determine the rate with which the large cell memory offered for this connection type as well as the other connection types (nrt-VBR, ABR, UBR) is allowed to be emptied.

30 Upon setup of an ATM connection, the transmitting means must generally inform a higher-ranking control means (all acceptance control) of previously defined parameters. This is required in order to assure the quality

of the connection for all subscribers (quality of service). When, for example, too many cells are transmitted and, thus, the transmission capacity is exceeded, too many cells must be discarded. This, however, must be avoided under all circumstances since this all involves a loss of information. To this end, for example, the demand for a cell loss properly of 10^{-10} of a connection exists on the part of standardization authorities. For this reason, a calculation is already carried out at the call setup as to whether this new connection can be accepted in addition to the connections already existing. When the transmission capacity has already been exhausted, the requested connection is rejected.

A number of transmission parameters are defined for the description of these procedures. These include, for example, the peak cell rate (PCR) defined on a connection. This is thereby a matter of an upper limit for the plurality of ATM cells that can be transmitted per second of this connection. Further, the control means is informed of a sustainable cell rate (SCR) by the transmitting means given a connection with variable bit rate. This is the upper limit for an average cell rate with which the cells are transmitted during the existence of the connection. As further parameters, the maximally possible transmission capacity of the connecting line (link cell rate, C) as well as the maximally possible load on the connecting line (p_0) are known to the control means. The former is a matter of a quasi material constant of the connecting line, whereas the latter defines a quantity with which the maximally allowable aggregate cell rate on the connecting line is recited. This is usually 95% of the maximally possible transmission capacity of the connecting line. Based on the measure of these parameters, a decision is then made as to whether new connection requests can be accepted or not.

To this end, an algorithm sequences in the higher-ranking control means with which the parameters received from the transmitting equipment are checked. Further, these are compared to parameters that have already been calculated and relate to the momentary load on the connecting line. A decision is then made on the basis of these comparisons as to whether the new connection request is accepted and this connection can still be

permitted. Among other things, the peak cell rate that has already been addressed or the sustainable cell rate are employed as critical parameters.

A number of methods have developed in the prior art for handling these procedures. Let the sigma rule algorithm be recited here as a simple method. This algorithm is disclosed in detail in German Patent Application DP 196 49 646.7. A n^{th} connection is thereby only allowed when the following is valid for the $(n - 1)$ connections already existing plus the n^{th} connection:

$$(a) \quad \sum_{i=1}^n PCR_i \leq p_0 \cdot C$$

The connection is likewise allowed when, taking additional properties of the n connections into consideration, as explained later, the following condition (b) is met.

$$(b) \quad \sum_{VC_i \in \text{class S}} SCR_i + g(c, \text{class S}) \cdot \left(\sum_{VC_i \in \text{class S}} SCR_i \cdot (PCR_i - SCR_i) \right)^{1/2} \leq$$

$$p_0 \cdot C - \sum_{VC_i \in \text{class P}} PCR_i$$

whereby $c = p_0 \cdot C - \sum PCR_i$ is the free capacity for class S.

It can be derived from condition (b) that the pending connections are divided into two classes here. At the beginning of the connection setup, thus, the sigma rule algorithm must make a decision as to which of two classes, namely a class S as well as a class P, the potentially newly added ATM connection is to be assigned to.

All virtual connections are assigned to class S for which a statistical multiplexing according to the sigma rule algorithm would yield a noticeable gain compared to the peak cell rate reservation algorithm. The following condition must be met as criterion for this type of connection for the peak cell rate and the sustainable cell rate of all connections to be statistically multiplex:

$$PCR/C < 0.03 \quad \text{and} \quad (0.1 \leq SCR/PCR \leq 0.5)$$

All other virtual connections are assigned to the class P. These particularly include the connections with constant bit rate. Further, all connections are assigned here for which the parameters SCR as well as PCR lie very close to one another - or very far from one another or that already exhibit a high peak cell rate PCR compared to the overall capacity of the connecting line. A peak cell rate that is greater than 3% of the maximally possible transmission capacity of the connecting line is valid as criterion for this.

Further, a factor q can be derived from the condition (b). This factor is dependent both on the class S as well as on the free capacity c of the class S. For a defined class S, the $q(c)$ values must be calculated with a complicated program. In simplifying fashion from dynamics points of view, the dependency of the quantity c is estimated by a hyperbola function $q(c)=q_1+q_2/c$.

In this prior art, thus, a n^{th} virtual connection VC_n having a defined peak cell rate PCR_n as well as a sustainable cell rate SCR_n is allowed in addition to already existing virtual connections VC_i having the parameters SCR_i as well as PCR_i ($1 \leq i \leq n-1$) on a connecting line when conditions (a) or (b) are met.

According to the condition (a), a check is carried out to see whether the sum of the peak cell rates of all n connections on the connecting line is equal to or less than the maximally possible transmission capacity on the connecting line. When this is the case, then n^{th} virtual connection can be accepted and the interrogation of condition (b) is superfluous. When this is not the case, then a check is carried in condition (b) to see whether the upper estimate of the average value of the sum of the peak cell rates of all connections of the class S together with a cell rate that is calculated from the burst nature of all connections of the class S is less than or equal to the cell rate that is available currently for class S connections. When this is the case, then the n^{th} virtual connection is accepted; otherwise, it is rejected.

In this prior art, the first class S is in turn subdivided into further sub-classes S_1 , S_2 or S_3 in order to achieve an even finer classification. In case

of the arrival of a new connection request, thus, the sigma rule algorithm must check based on the criterion of determined interrogation criteria to see which of the sub-classes this new connection is to be assigned to.

The most beneficial sub-class S_x is then automatically selected. A sub-class S_x is thereby defined via a lower limit or, respectively, upper limit of the peak cell rate PCR as well as of the relationship of the transmission parameters SCR/PCR.

Equation (b) thus experiences a modification by the addressed sub-classes S_k, P_k

$$(c) \quad \sum_{VC_i \in S_k} SCR_i + q(c, S_k) \cdot \sqrt{\sum_{VC_i \in S_k} SCR_i \cdot (PCR_i - SCR_i)} \leq c$$

whereby $c = p_0 \cdot C - \sum_{VC_i \in P_k} PCR_i$ is the free capacity for the class S.

The q factor thus derives as $q(c, S_k) = q^1_{S_k} + q^2_{S_k} / c$

This connection acceptance algorithm according to this prior art is thus in the position of deciding whether a predetermined bandwidth, for example the bandwidth of a virtual path or of a line, is adequate overall for a group of connections. Since such acceptance algorithms supply a yes/no decision as a result as to whether a connection is to be accepted or not, they are not directly suited for the calculation of the effective bandwidth for a group of connections.

The effective bandwidth required for a group of connections according to the used sigma rule acceptance algorithm could fundamentally be determined with arbitrary precision by an iterative approximation method. The problem of this method, however, is comprised therein that the acceptance algorithm would have to be multiply run per connection setup and, thus, would require an extremely great amount of processor capacity.

European Patent Application EP 0 673 138 A2 discloses a method of how a plurality of connections can be conducted over a common

connecting section. Upon arrival of a connection request, a check is thereby carried out to see if adequate bandwidth is still available for accepting this connection. When this is the case, the connection is accepted; otherwise, it is rejected. The calculation of an effective bandwidth, however, is not addressed here.

International Application WO 97/01895 likewise discloses a method of how pending connections are conducted via common connecting sections. The goal of such an algorithm, however, is only to accept or, respectively, reject the connection based on the criterion of the remaining bandwidth.

The invention is based on the object of disclosing a way of how an acceptance algorithm is to be fashioned such that a bandwidth representative for all connections can be calculated in an efficient way.

Proceeding on the basis of the features recited in the preamble of patent claim 1, the invention is achieved by the features of the characterizing part.

What is particularly advantageous for the invention is that the sigma rule algorithm is employed as acceptance algorithm. The bandwidth, proceeding from an initial value, is determined step-by-step with the setup/release of connections. The sigma rule algorithm is started at every step and, in addition to supplying a yes/no decision, supplies an estimate of the bandwidth based on the prescription of acceptance criteria, a conservative traffic parameter value of a class-specific bandwidth is added or, respectively, subtracted. The conservative traffic parameter value is thereby constructed differently in the case of the connection setup than in the case of the connection release. When the sigma rule algorithm determines that the conservative estimate with respect to the bandwidth would be adequate, then a more aggressive traffic parameter value is added to or, respectively, subtracted from the class-specific bandwidth. Here, too, the more aggressive traffic parameter value is fashioned differently in the case of the connection setup than in the case of the connection release.

Advantageous developments of the invention are recited in the subclaims.

The invention is explained in greater detail below with reference to an exemplary embodiment.

Shown are:

Fig. 1 a flow chart according to the inventive method;

Fig. 2 a flow chart according to the inventive method.

Fig. 1 shows a flow chart of the inventive method. The initially described sigma rule algorithm SR of the prior art is employed as acceptance algorithm. In accord therewith, additional status variables are introduced in addition to the status variable carried in the sigma rule algorithm SR. What are thereby involved are a matter of the status variables c_k^S , c_k^P and c_k^{eff} .

The status variables c_k^S is a matter of the effective bandwidth of the virtual connections that are to be assigned to one of the classes S_k according to the sigma rule algorithm SR. The status variables c_k^P indicates the sum of the peak cell rates PCR of all virtual connections in the class P_k , whereas the status variables c_k^{eff} is defined as effective bandwidth of all connections with reference to the classes k . What thus follows is:

$$(1) \quad c_k^{\text{eff}} = c_k^S + c_k^P$$

Given $(n-1)$ existing connections VC_i with the parameters PCR_i , SCR_i , a calculation is then carried out for a connection setup to see whether 1) the new connection VC_n can be accepted or not; 2) the effective bandwidth c_k^{eff} that are [sic] to be reserved for the $(n-1)$ existing connections VC_i including the newly added connection VC_n .

In a first step, a check is first carried to see whether the new connection VC_n to be potentially accepted can be assigned to one of the classes S_k or P_k . For example, let it be assumed that this can be assigned to one of the classes S_k . In this case, a check is carried out to see whether the following condition is met for all virtual connections VC_i , including the connection to be potentially added:

$$(2) \quad \sum_{VC_i \in S_k} SCR_i + q(c^{S_k} + SCR_n, S_k) \cdot \sqrt{\sum_{VC_i \in S_k} SCR_i \cdot (PCR_i - SCR_i)} \leq c^{S_k} + SCR_n$$

In the above equation, Equation (c) is taken as the basis and the variable c employed therein is replaced by the bandwidth c_k^S reserved for the $(n-1)$ connections plus the average sustainable cell rate SCR_n that is to be reserved for the n^{th} connection VC_n to be potentially accepted. As can be seen according to Fig. 1, the method is started with a value $c_k^S = 0$.

A strict application of condition (2) likewise yields a bandwidth that is greater than the sum of the peak cell rate PCR_n of all connections. Since the sum of all added, effective bandwidths, however, is never allowed to lie above the sum of its peak cell rates PCR_n , condition (2) is modified in such a way that

$$(3) \min \left[\sum_{VC_n \in S_k} SCR_i + q(c^{S_k} + SCR_n, S_k) \cdot \sqrt{\sum_{VC_n \in S_k} SCR_i \cdot (PCR_i - SCR_i)}, \sum_{VC_n \in S_k} PCR_i \right]$$

$$c_k^S + SCR_n$$

is taken. A security in the estimate is thus established.

When the above condition applies, then the effective bandwidth employed up to then plus the sustainable cell rate SCR_n allowed for the n^{th} connection VC_n is taken as new, effective bandwidth c_k^S . As a result thereof, the following derives:

$$(4) \quad c_k^S := c^{S_k} + SCR_n$$

When the condition (3) is not met, the effective bandwidth employed up to then plus the peak cell rate PCR_n allowed for the n^{th} connection VC_n is taken as new, effective bandwidth c_k^S .

$$(5) \quad c_k^S := c^{S_k} + PCR_n$$

When the new connection VC_n to be potentially added is to be allocated to one of the classes S_k , a value for the effective bandwidth c_k^{eff} has thus been found.

When the new connection VC_n to be potentially added cannot be assigned to one of the classes S_k , it is automatically assumed that it is to be allocated to one of the classes P_k . The following thus derives:

$$(6) \quad c_k^{P_k} := c^{P_k} + PCR_n$$

Upon employment of Equation (1), the effective bandwidth c_k^{eff} can then be calculated:

$$C^{eff_k} = C^{S_k} + C^{P_k}$$

An effective bandwidth has thus been found for the case of a connection setup.

Subsequently, it then must also be determined whether the new connection VC_n can be accepted. To this end, the condition

$$C^{eff_k} \leq PO \cdot C$$

must be met.

It is assumed below according to Fig. 1 that a connection release is to be implemented. It is thereby assumed that a connection VC_n is released given n existing connections VC_i having the parameters PCR_i , SCR_i .

Given release of the connection, a check is first carried out to see whether this appertaining connection VC_n was allocated to one of the classes S_k . In this case, an interrogation criterion is applied to all remaining virtual connections VC_i (accept the connection VC_n) according to condition (7):

$$(7) \quad \sum_{VC_i \in S_k} SCR_i + q(c^k - PCR_n, S_k) \cdot \sqrt{\sum_{VC_i \in S_k} SCR_i (PCR_i - SCR_i)} \leq c^k - PCR_n$$

A strict application of condition (7) now potentially yields a bandwidth for the remaining $(n-1)$ connections that is greater than the sum of the peak cell rates of the connections. Condition (7) is therefore to be modified in such a way that

$$(8) \min \left[\sum_{VC_n, S_k} SCR_i + q(c^{S_k} - PCR_n, S_k) \cdot \sqrt{\sum_{VC_n, S_k} SCR_i \cdot (PCR_i - SCR_i)} \cdot \sum_{VC_n, S_k} PCR_i \right] \leq c^{S_k} - PCR_n$$

derives.

When the above condition applies, then the effective bandwidth applied up to then minus the peak cell rate PCR_n allowed for the n^{th} connection VC_n is taken as new, effective bandwidth c_k^s . Deriving therefrom is:

$$(9) \quad c_k^{S_k} = c^{S_k} - PCR_n$$

When condition (8) is not met, then the effective bandwidth employed up to then minus the sustainable cell rate SCR_n for the n^{th} connection VC_n is taken as new effective bandwidth c_k^s .

$$(10) \quad c_k^{S_k} = c^{S_k} - SCR_n$$

A value for the effective bandwidth c_k^{eff} has been found for the released connection VC_n that was allocated to one of the classes S_k .

When the released connection VC_n was not allocated to one of the classes S_k , it is automatically assumed that it was allocated to one of the classes P_k . The following thus derives:

$$(11) \quad c_k^{P_k} = c^{P_k} - PCR_n$$

Upon application of Equation (1), the effective bandwidth c_k^{eff} can then be calculated:

$$c_k^{eff} = c^{S_k} + c^{P_k}$$

In one development of the invention, it is provided to replace Equation (10) with

5 Upon release of connections that were allocated to one of the classes S_k , the value of the class-specific bandwidth c_k^S is thus upwardly limited by the sum of the peak cell rate of all connections allocated to the classes S_k . The corresponding conditions are shown in Fig. 2

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PATENT CLAIMS

1. Method for statistical multiplexing of ATM connections, comprising

5 a plurality of ATM connections that are conducted over a common connecting line and for which an effective bandwidth (c_k^{eff}) is reserved in aggregate on this connecting line for this purpose, as well as with an acceptance algorithm (SR) by which, given arrival of a connection request of a further connection to be potentially added, this is allocated to a first (S_k) or second class (P_k) and by which, in conjunction with acceptance criteria plus a bandwidth to be adhered to, a decision is made as to whether this
10 further connection to be potentially added can still be accepted on the common connecting line, characterized in that, proceeding from an initial value, the effective bandwidth (c_k^{eff}) is identified step-by-step with the setup/release of connections in that the acceptance algorithm (SR) is started at every step, and a first bandwidth (c_k^S) representative of the first class (S_k) and a second bandwidth (c_k^P) representative of the second class (P_k) is defined, and, based on the measure of the allocation of the connection, into consideration to one of the two classes (S_k , P_k) as well as of at least one acceptance criterion (c_k^{eff}), the first or second bandwidth (c_k^S , c_k^P) is modified
15 by a first (SCR) or by a second traffic parameter value (PCR).
20

2. Method according to claim 1, characterized in that the first traffic parameter value is the sustainable cell rate (SCR) and the second traffic parameter value is the peak cell rate (PCR) of the appertaining connection.

25 3. Method according to claim 1 or 2, characterized in that one of the acceptance criteria is fashioned such in the case of the connection setup that, when the connection to be potentially newly added can be allocated to the first class (S_k), a calculation is carried out to see whether the first bandwidth (c_k^S) identified in the preceding step is adequate including this
30 connection, whereby it is assured that the calculated, first bandwidth dare

not exceed the sum of the peak cell rates of all connections; and in that, when the acceptance criterion is met, the first bandwidth (c_k^s) is incremented by the first traffic parameter value (SCR_n) and is otherwise incremented by the second traffic parameter value (PCR_n).

5 4. Method according to claim 3, characterized in that, when the connection to be potentially newly added cannot be allocated to the first class (S_k), this is automatically allocated to the second class (P_k) and the second bandwidth (c_k^p) is incremented by the second traffic parameter value (PCR_n).

10 5. Method according to claim 1, 2, characterized in that the acceptance criterion is fashioned such in the case of a connection release that, when the connection to be released was allocated to the first class (S_k), a calculation is carried out to see whether the first bandwidth (c_k^s) calculated in the previous step and exclusive of this connection is adequate for the remaining connections, whereby it is assured that the calculated, first bandwidth dare not exceed the sum of the peak cell rates of all connections; and in that, when the acceptance criterion is met, the first bandwidth (c_k^s) is diminished by the second traffic parameter value (PCR_n) or is otherwise diminished by the first traffic parameter value (SCR_n).

20 6. Method according to claim 5, characterized in that, when the connection to be released was not allocated to the first class (S_k), it is automatically assumed that this was allocated to the second class (P_k) and, in this case, the second bandwidth (c_k^p) is diminished by the second traffic parameter value (PCR_n).

25 7. Method according to claim 5, characterized in that the acceptance criterion is fashioned such in the case of a connection release that, when the connection to be released was allocated to the first class (S_k), a calculation was carried out to see whether the first bandwidth (c_k^s)

determined in the previous step and minus this connection is adequate for the remaining connections; and in that, when the acceptance criterion is met, the first bandwidth (c_k^S) is diminished by the second traffic parameter value (PCR_n) or, otherwise, the value of the identified first bandwidth (c_k^S) is upwardly limited by the sum of the peak cell rates of the first class (S_k).

8. Method according to one of the preceding claims, characterized in that the effective bandwidth (c_k^{eff}) derives from the sum of the first (c_k^S) and second (c_k^P) bandwidth.

9. Method according to one of the preceding claims, characterized in that the acceptance algorithm (SR) is started only once per connection to be potentially added or, respectively, released.

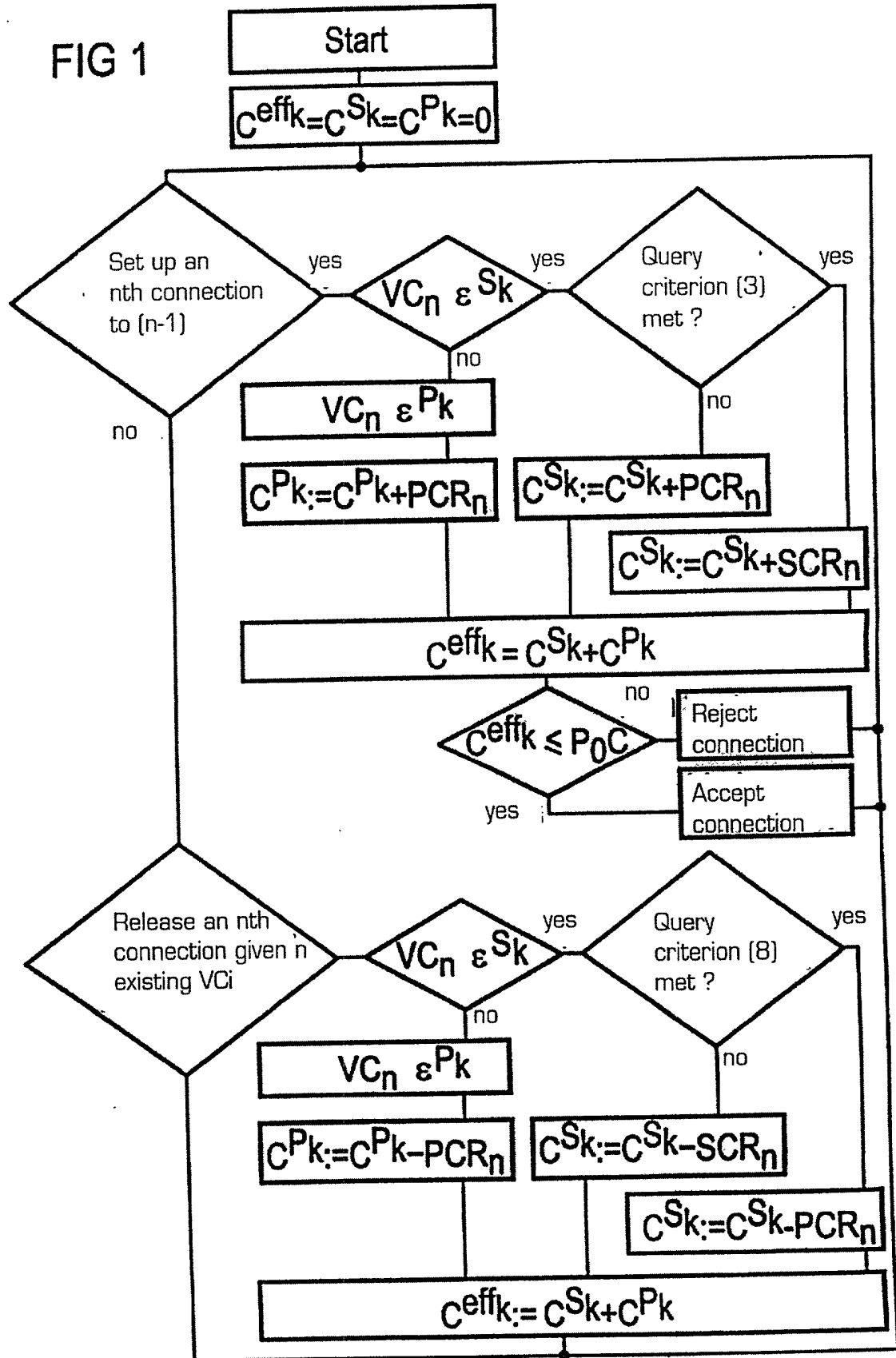
ABSTRACT**Method For Statistical Multiplexing Of ATM Connections**

Given ATM connections, a plurality of connections are transmitted over common connecting sections. Connections being newly added thereto are allowed according to the criterion of decisions undertaken by acceptance algorithms. However, only yes/no decisions are thereby made. Often, however, the knowledge of the bandwidth for the totality of all connections conducted over these connecting sections is necessary. The invention solves this problem in that the bandwidth is estimated step-by-step with the setup/release of connections upon modification of the sigma rule algorithm.

Fig. 1

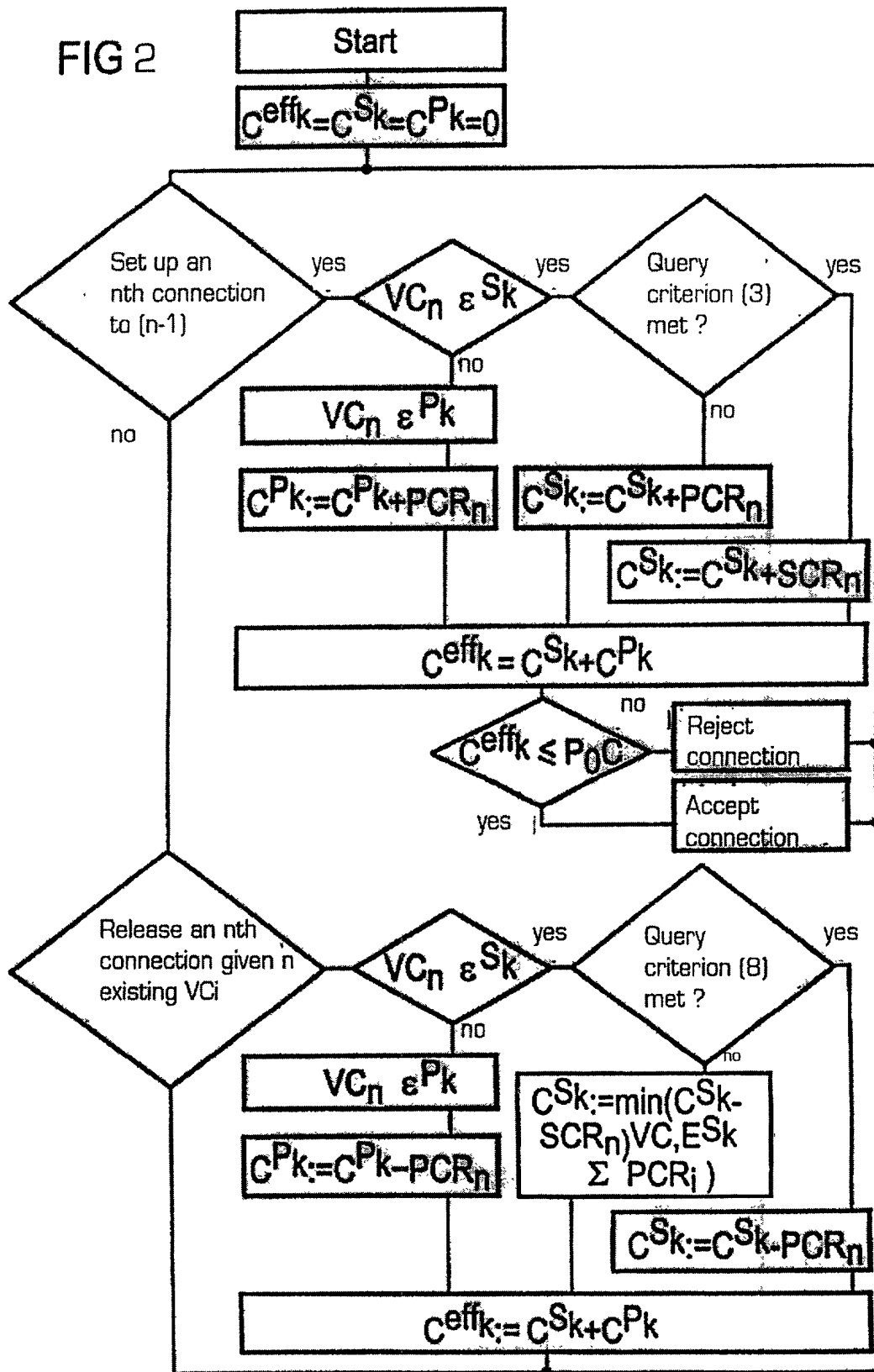
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FIG 1



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FIG 2



Declaration and Power of Attorney For Patent Application

Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren zum statistischen Multiplexen von ATM-Verbindungen

deren Beschreibung

(zutreffendes ankreuzen)

☒ hier beigelegt ist.

☐ am _____ als

PCT internationale Anmeldung

PCT Anmeldeungsnummer _____

eingereicht wurde und am _____

abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

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PCT Application No. _____

and was amended on _____

(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign applications
Priorität beansprucht

Priority Claimed

197 35 166.2 Germany 13. August 1997
(Number) (Country) (Day Month Year Filed)
(Nummer) (Land) (Tag Monat Jahr eingereicht)

☒ ☐
Yes No
Ja Nein

(Number) (Country) (Day Month Year Filed)
(Nummer) (Land) (Tag Monat Jahr eingereicht)

☐ ☐
Yes No
Ja Nein

(Number) (Country) (Day Month Year Filed)
(Nummer) (Land) (Tag Monat Jahr eingereicht)

☐ ☐
Yes No
Ja Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

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(Application Serial No.)
(Anmeldeseriennummer)

(Filing Date)
(Anmeldedatum)

(Status)
(patentiert, anhängig,
aufgegeben)

(Status)
(patented, pending,
abandoned)

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(Anmeldeseriennummer)

(Filing Date)
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German Language Declaration

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

And I hereby appoint

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(Supply similar information and signature for third and subsequent joint inventors).